DSP SW / Multimedia SW
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21.11.2000

STUDY REPORT

ABSTRACT

This study concerns General Midi bank instruments and very small loudspeakers with limited amplifier power. The aim is to find out which instruments sounds good when played through small loudspeaker. We also wanted to determine the characters that make the sound functional.

It was found that there is possibility to make low notes hearable by selecting the right instrument. If we use for instance Piano 1, Clavi, Church organ, Reed Organ, Distortion Guitar, Slap Bass 1 or Baritone Sax the lowest notes are fairly useful and in most of the cases the instrument is recognizable.

The number of instruments used simultaneously should not be very big when using tiny loudspeaker. One single instrument produces usually the clearest outcome.

Very often synthetic sounds produces better outcome than synthesized acoustical instruments.

This study shows that very useful instruments are Bird, Woodblock Telephone, Piccolo, Clav., Tinkle Bell, Steel Drums, Agogo, Flute, Whistle, Xylophone, Sweep Pad, Goblin, Accordion, Koto, Shamisen, Piano 2, Marimba, Charang, Bowed Glass.

Correspondingly following instruments didn’t qualify well and the use should be avoided: Acoustic Bass, Timpani, Melo Tom, Tuba, Taiko, Synth Drum, Fingered Bass, Picked Bass, Synth Bass 1, Bassoon, Synth Bass 2, Viola, Violin, Contrabass, Choir Aahs, Nylon String, Tremolo Str, Clean Guitar, Jazz Guitar.

We wanted to give also a guide how to reduce GM bank if needed. Following instruments are the twenty first ones to leave out (substitute instrument in brackets):

Acoustic Bass, Timpani, Melo Tom, Tuba, Taiko, Synth Drum, Picked Bass, Bassoon, Synth Bass 2, Breath Noise, Clean Guitar (Jazz Guitar), Synth Strings 2 (Synth Strings 1), Slap Bass 2 (Slap Bass 1), Syn Vox (Solo Vox), Synth Brass (Brass 1), Overdrived Guitar (Distortion Guitar), Kalimba (Marimba), English Horn (Oboe), Piano 2 (Piano 1), Reed Organ 1 (Accordion).

Bottom line: Information transference is the key concept. If the speaker is small and amplifier low-powered then the system can't produce very big information flow.

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1. INTRODUCTION

Research problems

Which instruments of GM bank sounds excellent or bad when played through very small loudspeaker like in mobile devices?

Which are the attributes of the sound that make the instrument functional or not functional when played through small loudspeaker?

2. PHYSICAL REMARKS

It is natural that instruments containing lots of low frequencies will lose the match. A research is not needed to prove this fact if the diameter of a loudspeaker is only a couple of dozen millimeters (or less).

The amplifier power in mobile devices is very restricted too. To gain maximum sound volume we have to take advantage of the resonance frequency of a loudspeaker. Luckily this frequency is typically within the most sensitive area of human hearing.

3. DESCRIPTION OF THE RESEARCH

3.1 Measuring equipment

The loudspeaker used was phone mockup with 13-mm loudspeaker inside. Because of the solid construction of the mockup the acoustics vary a bit from actual phone but not very much. This issue is beyond the study.

Amplifier was a specially designed circuit (LM4877) powered by a standard lab power supply. This was adjusted to the 3,60 V (DC).

A pair of Genelec 1030A active monitors was used as reference system to evaluate the changes in sound when mockup is used. In both cases the input signal was routed through a mixing board Mackie 1202-VLZ Pro.

For a live testing of midi player there were Roland PC-180 midi controller and Opcode MIDI Translator PC –midi interface.

There were two different configurations, which were measured separately:

- In the first case the sound source was Beatnik's midi player and editor version 2.0a66. This player is widely used in web-solutions and it has to be quite light and memory saving. Therefore the samples are short and some samples are used in several instruments.

- The reference source was sound module Roland SC-88Pro. During testing the LSB Bank was 0 so only the basic GM samples were used. There were no reverb and chorus and volume and expression were set to 100.

3.2 Performed measurements

Three different things were measured in both configuration cases: **audibility** of a sound, **identifiability** of instrument and **similarity** with the reference speaker. There were also evaluations about how nice the sound is and what is the general musical functionality but those results were left out because of too strong dependency on test person.

Audibility was measured with human ears i.e. how loud an instrument sounds just before the distortion appears. There was not used decibel or any other acoustical pressure meter because we wanted to find out just those results, which can't be measured mechanically. Even if decibel meter shows the same reading for two sounds they can still sound different in volume for human.

Identifiability was determined without reference speaker. Each instrument was given a score according to how easy it was to recognize the original instrument.

Similarity was determined with human ears as well. Test patterns (see next paragraph) were played from mockup and reference by turns and also simultaneously. Two things were evaluated: 1. If mockup is playing and reference is added then does reference bring anything new to the sound and if it does then how much? 2. Is it possible to say without knowing which one is playing, mockup or reference?

There were three kinds of test patterns used in evaluations. We used major scale from midi note 33 (A1) to midi note 93 (A5) and back. For certain instruments there were also pieces of midi music. The third test situation was live playing which was used with all instruments.

4. RESEARCH RESULTS

The complete measurement data is presented in appendices. In the file MockupEvaluationForm041000BAE.xls there is data and complete ranking lists for Beatnik engine. In the file MockupEvaluationForm041000SC88Pro.xls there are the ones for SC88Pro. In the latter file there are also Beatnik ranking lists and calculated audibility averages from both measurements. There is also the Q-number of each instrument at the far right of the sheet. The Q-number is an average calculated from four numbers: Beatnik identifiability and similarity and SC88Pro identifiability and similarity. Audibility is left out from the average, because loudness is not always important feature. An instrument can be very useful even though it wouldn't be loud alone.

4.1 General notices

- As stated above all the basses are moreless too quiet. There is still *possibility to make low notes hearable* by selecting the right instrument. If we use for instance Piano 1, Clavi, Church organ, Reed Organ, Distortion Guitar, Slap Bass 1 or Baritone Sax the lowest notes are fairly useful and in most of the cases the instrument is recognizable. This can be explained by the great amount of harmonic frequencies in these sounds. However, the use of these instruments as bass will decrease the amount of information, which can be transmitted by other simultaneously ringing instruments to the listener.

- One important issue is the *number of instruments used simultaneously*. This number should not be very big. The amount of information delivered per unit of time is quite limited in a small loudspeaker. We have found that in most cases one single instrument gives the best and clearest image of the music to the listener. It is acceptable to have two or three layered instruments but a big symphony orchestra will probably sound terrible. Of course instrument choices, mixing and effecting will affect to the outcome a bit.

- It seems that very often *synthetic sounds do better than synthesized acoustical* ones. This could came from the fact that waveforms of acoustical instruments are usually very complex. Acoustic instrument sounds also have to carry lots of information with them. Instrument has to be recognizable. Listener has to notice the link between sound and physical instrument, which may not happen if the sound doesn't remind the original instrument enough. The listener also have to be able to distinguish if the instrument is played hard or softly which is sometimes quite tiny change in the sound. Otherwise it is hard to catch the atmosphere changes. Synthetic sounds (Square wave, Saw wave, Sin wave etc.) don't usually meet so numerous expectations in information transforming.

4.2 The best and the worst in quality

4.2.1 The best

Rankin	Name	#	Q	Rankin	Name	#	Q
1	Bird	124	8,9	21	Warm pad	90	6,2
2	Wood Block	116	8,6	22	Glockenspiel	10	6,1
3	Telephone	125	8,3	23	Church Organ	20	6,1
4	Piccolo	73	7,9	24	Voice Oohs	54	6,1
5	Clav.	8	7,8	25	Reverse Cym	120	6,1
6	Tinkle Bell	113	7	26	Piano 1	1	6
7	Steel	115	7	27	Ocarina	80	6
8	Agogo	114	6,9	28	Helicopter	126	6
9	Flute	74	6,8	29	Polysynth	91	5,9
10	Whistle	79	6,8	30	Square Wave	81	5,9
11	Xylophone	14	6,7	31	Banjo	106	5,9
12	Sweep Pad	96	6,7	32	Trumpet	57	5,8
13	Goblin	102	6,7	33	Oboe	69	5,8
14	Accordion	22	6,4	34	Bag Pipe	110	5,8
15	Koto	108	6,4	35	Shanai	112	5,8
16	Shamisen	107	6,4	36	Tango Acd	24	5,8
17	Piano 2	2	6,3	37	Sitar	105	5,8
18	Marimba	13	6,3	38	Honky-tonk	4	5,7
19	Charang	85	6,3	39	Syn Calliope	83	5,7
20	Bowed	93	6,3	40	Ice Rain	97	5,7

4.2.2 The worst

Rankin	Name	#	Q	Rankin	Name	#	Q

128	Acoustic	33	1,5
127	Timpani	48	1,5
126	Melo Tom	11	1,9
125	Tuba	59	2
124	Taiko	11	2,2
123	Synth Drum	11	2,2
122	Fingered	34	2,2
121	Picked Bass	35	2,3
120	Fretless Bass	36	2,3
119	Synth Bass 2	40	2,3
118	Bassoon	71	2,4
117	Synth Bass 1	39	2,5
116	Viola	42	2,7
115	Violin	41	2,9
114	Contrabass	44	3,1
113	Choir Aahs	53	3,3
112	Nylon String	25	3,4
111	Tremolo Str	45	3,4
110	Clean Guitar	28	3,4
109	Jazz Guitar	27	3,5

108	Cello	43	3,6
107	Synth Strings	52	3,7
106	Draw Organ	17	3,9
105	Soprano Sax	65	3,9
104	Slap Bass 2	38	4
103	Steel String	26	4,1
102	Syn Vox	55	4,1
101	Pizzicato Str	46	4,1
100	Applause	127	4,1
10	Synth Brass 2	64	4,2
91	Muted Guitar	29	4,2
9	5th Saw Wave	87	4,2
9	Tenor Sax	67	4,3
9	Guitar	32	4,4
9	French Horn	61	4,4
9	Synth Brass 1	63	4,4
9	Strings	49	4,4
9	Bass&Lead	88	4,4
9	Pan Flute	76	4,5
9	Sea Shore	123	4,5

4.2.3 Reducing the GM bank

We wanted to list those instruments that could be reduced from GM bank without any or with small losses in bank versatility. We used two methods in defining this list:

1. List the instruments that have found bad during this study.
2. If two instruments are difficult to distinguish or their musical function is the same then one can be left out.

However, all the bad quality instruments weren't listed because of their importance; this concerns violin, viola, cello, contrabass and most of the guitars for instance.

List 1:

Breath Noise	122

Name	**#**
Acoustic Bass	33
Timpani	48
Melo Tom	118
Tuba	59
Taiko	117
Synth Drum	119
Picked Bass	35
Bassoon	71
Synth Bass 2	40

List 2:

Name	**#**	**Replace**
Clean Guitar	28	Jazz guitar
Synth Strings 2	52	Synth strings
Slap Bass 2	38	Slap Bass 1
Syn Vox	55	Solo vox

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Synth Brass 1	63	Brass 1
Overdrived	30	Distortion
Kalimba	109	Marimba

English Horn	70	Oboe
Piano 2	2	Piano 1
Reed Organ 1	21	Accordion

4.3 Best and worst in audibility

Best:

Name	#
Distortion	31
Bag Pipe	11
Clav.	8
Church Organ 1	20
Overdrived	30
Charang	85
Violin	41
Trumpet	57
Square Wave	81
Polysynth	91

Worst:

Name	#
Synth Drum	11
Melo Tom	11
Pizzicato Str	46
Acoustic Bass	33
Breath Noise	12
Tuba	59
Synth Bass 2	40
Synth Bass 1	39
Harp	47
Frestless Bass	36

5. RELIABILITY OF THE STUDY

This document is intentionally entitled *study* because there is not used any known theorem base concerning study reliability. It is very laborious to evaluate all the GM bank sounds twice in proportion to five different quantities using several different test patterns. Therefore sample in this study is quite small. However, this is not statistical inspection so the sample size is not so crucial.

Every sound designer of bank engineer who reads this is advised to use this document as guideline but still listen carefully the instruments when doing his work and using this document.

6. CONCLUSION

The results are mainly presented in chapter 4.

See Abstract for shorter version.

APPENDICES

File: MockupEvaluationForm041000BAE.xls

File: MockupEvaluationForm041000SC88Pro.xls